CERTIFICATE OF VERIFICATION

I, Soo Jin KIM of 648-23 Yeoksam-dong, Gangnam-gu, Seoul, Republic of Korea state that the attached document is a true and complete translation to the best of my knowledge of the Korean-English language and that the writings contained in the following pages are correct English translation of the specification and claims of the Korean Patent Application No. 10-1999-0018900.

Dated this 30th day of January, 2007.

Signature of translator: ______________________

Soo Jin KIM

KOREAN INTELLECTUAL PROPERTY OFFICE

This is to certify that the following application annexed hereto is a true copy from the records of the Korean Industrial Property Office.

Application Number : Patent Application No. 1999-18900

Date of Application : May 25, 1999

Applicant(s) : LG Electronics Inc.

COMMISIONER

[ABSTRACT OF THE DISCLOSURE]

[ABSTRACT]

The present invention relates to an apparatus and method for recording/reproducing of optical recording medium. Since the potential difference of a tracking error signal detected in a header field staged with respect to each other from a track center varies in accord with tilt, by using this characteristic, tilt is detected and compensated from variation of the potential difference of the tracking error signal during recording/reproducing actual data. Therefore, tilt can be detected and compensated in a stable and accurate manner without using a separate light-receiving element in a high-density optical disc and deterioration of data quality caused by tilt during a recording/reproducing operation can be prevented and stable operation of the system can be possible by preventing detrack caused by tilt.

[TYPICAL DRAWING]

FIG. 2

[INDEX WORDS]

tilt, tracking error

[SPECIFICATION]

[TITLE OF THE INVENTION]

METHOD AND APPARATUS FOR RECORDING/REPRODUCING OF OPTICAL RECORDING MEDIUM

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is a diagram showing an arrangement of a header preformatted at the beginning position of each sector in a general rewritable disc.

FIG. 2 is a block diagram showing a structure of an optical disc recording/reproducing apparatus for controlling tilt in accordance with the present invention.

FIG. 3 is an exemplary diagram showing an optical detector of the optical pickup shown in FIG. 2.

FIG. 4 is an exemplary graph showing tracking error signals detected at a header 1,2 field and a header 3,4 field depending on variation of a tilt.

FIGS. 5a to 5c are exemplary diagrams showing the level variation of tracking error signals detected at a header 1,2 field and a header 3,4 field depending on variation of a tilt.

Reference numerals of the essential parts in the drawings

201 : optical disc

202 : optical pickup

203 : RF signal and servo error signal generator

204 : tilt detector

205 : servo controller

206 : tilt operator

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The present invention relates to a high-density optical recording medium system, and more particularly, to a method for controlling tilt, capable of detecting and compensating for tilt of the optical recording medium.

In general, a repetitively and freely rewritable optical recording medium, for example, an optical disc includes rewritable compact disc (CD-RW) and rewritable digital versatile disc (DVD-RW, DVD-RAM, DVD+RAM).

These rewritable optical mediums, particularly, optical discs have signal tracks made up of lands and grooves and enable the tracking control of an empty disc on which no information signal is written. Recently, information signals are also written on the tracks of lands and grooves so as to enhance recording density. For this purpose, the recent optical pickup for recording and reproducing information signals uses the shorter wavelength of laser beam with an increased number of

apertures formed in the object lens and thereby reduces the size of beam for recording/reproducing.

In order to achieve higher recording density, such a rewritable high-density optical disc is designed to have a reduced distance between the signal tracks, i.e., the smaller signal track pitch.

For the rewritable discs, it is naturally impossible to perform a disc control and a recording operation in an empty disc in which no information is written. Thus disc tracks are formed in lands and grooves to write information on, and control information for random access and rotation control is separately recorded in the disc, so as to enable tracking control in the empty disc.

The control information is, as shown in FIG. 1, written on the header pre-formatted at the beginning position of each sector, or along the track in the wobbling profile. The term "wobbling" as used herein refers to recording the control information on the boundary of tracks in accord to variation of laser beam by supplying power of laser diodes with information for modulating a predetermined clock and applying the modulated clock to the disc, e.g., information about a desired position and the rotational speed of the disc.

The header preformatted at the beginning position

of each sector includes four header fields (header 1 field, header 2 field, header 3 field and header 4 field). At this time, the four header fields are staggered with respect to each other from the track center. FIG. 1 shows an example of the header for the first sector in a track. Referring to FIG. 1, the track boundary of the user area in which data are actually written has a wobbling profile.

During a resin extracting and gardening process in fabrication of the optical disc, distortion may take place in the optical disc and cause eccentricity even when a central aperture is perforated in optical disc. Also, deviation of the central aperture causes eccentricity although the tracks of the disc are accurately provided in the radial form with a defined pitch. Thus as the disc turns with eccentricity, the central axis of the motor is not in perfect accord with the center of the track.

It is thus hard to read out the signals of a desired track only. So, in the CD and DVD systems, a tracking servo is performed according to the standards established for the deflected quantity such that the beam always traces the desired track in spite of eccentricity.

It means, the tracking servo generates electrical signals corresponding to the beam trace status and moves the object lens or the optical pickup body in the radial direction based on the generated electrical signals, to

change the position of the beam and make the beam trace the accurate track.

Meanwhile, the beam can be deflected from a desired track due to a tilt of the disc as well as the eccentricity. This results from a mechanic error occurring when the disc is set on a spindle motor. That is, the focusing direction is not in perpendicular relation with the tracking direction. This slant state of the disc is called "tilt".

Tilt is not so significant for compact discs that have a large tilt margin due to their wide track pitch. The term "tilt margin" as used herein refers to a compensable quantity of tilt of the disc. However, with a growing need of densification of the optical appliances such as optical discs, especially in the DVD having the narrower track pitch, a slight tilt of the disc causes the beam to shift to the adjacent track due to a small radial tilt margin for the fitter. This detrack is unavoidable by the tracking servo only. That is, the tracking servo may mistake that the beam is tracing the accurate track even when the beam is shifted to the adjacent track due to tilt, while focusing on the center of the track.

This makes it impossible to read data accurately when reproducing, and to write data accurately in a desired track when recording. Thus a double distortion

occurs when reproducing the erroneously written data.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

To cope with this problem, there has been suggested a method in which the tilt of the disc can be detected with a dedicated tilt sensor, e.g., a tilt light-receiving device in an optical pickup. However, the method is not so efficient with a large size of the set.

Accordingly, the present invention is directed an apparatus and method for recording/reproducing of optical recording medium that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide an apparatus and method for recording/reproducing of optical recording medium, capable of detecting and compensating for defocus from header areas staggered with respect to each other.

[SYSTEM AND OPERATION OF THE INVENTION]

To achieve the above objects of the present invention, in an optical recording medium arranging a plurality of header areas being difference in phase as the non-writable areas for dividing shape of data area between writable data areas, a method for recording/reproducing of

an optical recording medium includes the steps of: determining whether a tracking error signal detected from areas having different phase in the non-writable area is symmetric or not based on the reference level; deciding as "tilt-zero" if it is determined to be symmetric and deciding as tilt is occurred if it is determined to be asymmetric and outputting the resulting value; and performing a tilt servo based on the resulting value.

The reference level is a tracking error signal detected from the data area.

The reference level is a track center of the tracking error signal.

The tilt servo step performs a tilt servo in order for two tracking error signals having different phases to be symmetric each other based on the reference level.

In an optical recording medium arranging a plurality of header areas being difference in phase as the non-writable areas for dividing shape of data area between writable data areas, a method for recording/reproducing of an optical disc includes the steps of: obtaining a difference value between a tracking error signal detected in the non-writable area and a reference level and outputting the resulting value to the 1 signal; obtaining a difference value between a tracking error signal detected in a non-writable area having difference phase to

the above non-writable area and the reference level and outputting the resulting value to the 2 signal; deciding as "tilt-zero" if difference value of the 1 and 2 signals at the above steps is below the definite reference value and as tilt is occurred if exceeding the definite reference value and outputting the resulting value; and performing a tilt servo from the resulting value.

The reference level at the above step is a center level of a tracking error signal detected from the data area.

The tilt servo performing step detects the magnitude of tilt from the difference value.

The tilt servo performing step detects the direction of tilt from the sign of the difference value.

The tilt servo performing step compensates tilt in a direction that the magnitude of the 1 and 2 signals are equalized.

In an optical recording medium arranging the 1 and 2 header areas being difference in phase for dividing shape of data area between writable data areas, an apparatus for recording/reproducing of an optical recording medium includes: a servo error generator for detecting tracking error signals from the 1 and 2 header areas, respectively, and outputting to the 1 and 2 tracking error signals; a tilt detector for detecting tilt

by variation of the potential difference signal between the 1 potential difference between the 1 tracking error signal and the reference level and the 2 potential difference between the 2 tracking error signal; and a tilt servo for compensating tilt detected from the tilt detector.

The reference level of the tilt detector is a center level of a tracking error signal detected from the data area.

The tilt detector determines as tilt is occurred if the 1 potential difference is in asymmetric relation with the 2 potential difference.

The tilt detector determines as "tilt-zero" if the difference value between the 1 potential difference and the 2 potential difference is below the definite reference value, and as tilt is occurred if the difference value exceeds the definite reference value.

The tilt detector detects the magnitude of tilt from the difference value between the 1 potential difference and the 2 potential difference and detects the direction of the sign and outputs the resulting value to the tilt servo.

The tilt detector detects tilt by normalizing the difference value between the 1 potential difference and the 2 potential difference.

The tilt servo performs a tilt servo in order for the 1 potential difference to have a symmetric relation with the 2 potential difference.

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

The present invention is directed to detection and compensation of tilt using level difference between a reference level and a tracking error signal detected in each header field having different phase each other, in a system that a header is staggered on the basis of track sectors.

FIG. 2 is a block diagram showing the structure of an optical disc recording/reproducing apparatus for performing tilt control method according to the present invention, in which only the principal parts related to tilt are shown.

Referring to FIG. 2, the optical disc recording/reproducing apparatus includes: a rewritable optical disc (201); an optical pickup (202) for recording/reproducing information on the optical disc (201); a RF and servo error generator (203) for generating an RF signal (or a read channel 1) and a servo error signal from electrical signals output from the optical pickup (202); a tilt detector (204) for detecting a tilt

from tracking error signals of the RF and servo error generator (203); a servo controller (205) for generating a tilt driving signal from the magnitude and the direction of tilt detected from the tilt detector (204); and a tilt driver (206) for controlling the optical pickup (202) based on the tilt driving signal to compensate for the tilt.

Herein, the optical pickup (202) has a split photo detector for detecting the quantity of light and converting the detected quantity of light to electrical signals. The split photo detector can be divided, as shown in FIG. 3, into a predefined number of optical detecting elements, e.g., four optical detecting elements PDA, PDB, PDC and PDD in the signal track direction and the radial direction of the optical disc (201).

In the present invention as constructed above, the optical disc (201) has signal tracks made up of lands and grooves, and data can be recorded/reproduced on the tracks of both the lands and the grooves as well as either the land tracks or the groove tracks. Also, at the beginning position of each sector, header 1 and 2 fields and header 3 and 4 fields are staggered with respect to each other in a free format. That is, the phases of the header 1 and 2 fields are in inverse relation with those of the header 3 and 4 fields.

Thus, while setting the optical disc (201), or during the recording/reproducing operation, the laser beam emitted from a laser diode of the optical pickup (202) is directed onto the signal tracks of the optical disc (201) and the beam reflected from the signal tracks of the optical disc (201) enters the split photo detector.

The split photo detector includes a plurality of optical detecting elements and outputs to the RF and servo error generator (203) electrical signal proportional to the quantity of beam obtained from the respective optical detecting elements.

The optical detector, if constructed as shown in FIG. 3, outputs to the RF and servo error generator (203) electrical signals a, b, c and d, each in proportion to the quantity of beam obtained from the respective optical detecting elements PDA, PDB, PDC and PDD.

The RF and servo error generator (203) combines the electrical signals a, b, c and d to generate an RF signal necessary for data reading, and a read channel 2 signal for servo controlling and a focus error signal, which are all necessary for a servo control. The RF signal is obtained by combining the electrical signals a, b, c and d from the split optical detector as a+b+c+d, and the read channel 2 signal is obtained by combining the electrical signals as (a+d)-(b+c). The tracking error signal is

obtained by processing the read channel 2 signal through filtering.

The split photo detector, if divided into two photodiodes (I1 and I2) in the direction of tracks, detects the RF signal (=I1+I2) and the read channel 2 signal (=I1-I2) from the beam quantity balance of both photodiodes. That is, in FIG. 3, a+d corresponds to I1 and b+c corresponds to I2.

The present invention also detects defocus using a level difference between tracking error signals detected at the header 1,2 field and the header 3,4 field staggered with respect to each other and a reference signal. The reference signal level is the center level of the tracking error signal detected at a user area.

For this, the tracking error (TE) signals among the servo error signals detected at the RF and servo error generator (203) are input to the tilt detector (204).

After sampling the tracking error signals output from the header 1,2 field and the header 3,4 field, the tilt detector (204) detects the level difference between the tracking error signals and the reference signal.

Table 1 shows the tracking error signal levels detected while varying tilt at fixed detrack and defocus offsets with focus and tracking on.

[Table 1]

Radial Tilt [°]	Header 1,2[V]	Header 3,4[V]
-1.0	0.70	3.30
-0.8	1.00	3.50
-0.6	1.50	3.50
-0.4	1.80	3.70
-0.2	2.20	3.40
0.0	2.20	3.10
0.2	2.40	3.10
0.4	2.40	2.90
0.6	2.40	2.60
0.8	2.20	2.40
1.0	2.10	1.80

FIG. 4 is a graph illustrating Table 1, in which it means that no tilt has occurred when the potential difference between the tracking error signal detected at the header 1,2 field and the reference signal is in symmetric relation with the potential difference between the tracking error signal detected at the header 3,4 field and the reference signal.

That is, the tracking error signals are significantly shifted up and down in the header field. For tracking error signals detected at the user area on which data is actually written, the two potential differences are almost equal to each other when no tile occurs, i.e., the beam is at the track center, whereas they are not equal to each other when tilt occurs, i.e., the beam

passes through the header 1,2 field and the header 3,4 field.

Thus whether tilt has occurred or not can be determined by comparing the potential difference between the tracking error signal at the header 1,2 field and the reference signal (tracking error signal potential at header 1,2 field - reference potential = Vp1) with the potential difference between the tracking error signal at the header 3,4 field and the reference signal (tracking error signal potential at header 3,4 field - reference potential = Vp2).

FIGS. 5a to 5c are exemplary diagrams showing tracking error signals varying depending on variation of the tilt offset with tracing and focus on. Referring to FIGS. 5a to 5c, the left-hand signal is the tracking error signal V_{HD12} detected at the header 1,2 field, the right-hand signal being the tracking error signal V_{HD34}. A voltage V_{TE} detected at the center level of the tracking error signal at the user area is preferably the voltage of the reference level.

In a case where no tilt occurs, the potential difference between the tracking error signal at the header 1,2 field and the reference level ($Vp1 = |V_{HD12} - V_{TE}|$) is almost equal to the potential difference between the tracking error signal at the header 3,4 field and the

reference level ($Vp2 = |V_{HD34} - V_{TE}|$), as shown in FIG. 5b. That is, the potential difference between the tracking error signal at the header 1,2 field and the reference level ($Vp1 = |V_{HD12} - V_{TE}|$) is in symmetric relation with the potential difference between the tracking error signal at the header 3,4 field and the reference level ($Vp2 = |V_{HD34} - V_{TE}|$).

This can be expressed by Equation 1.

[Equation 1]

$$|V_{HD12} - V_{TE}| \approx |V_{HD34} - V_{TE}|$$

It is determined that tilt has occurred, when the potential difference (Vp1) between the tracking error signal at the header 1,2 field and the reference level is not equal to the potential difference (Vp2) between the tracking error signal at the header 3,4 field and the reference level, as shown in FIGS. 5a and 5c, i.e., the potential difference Vp1 is in asymmetric relation with to the potential difference Vp2. The asymmetry increases with greater magnitude of tilt.

This can be expressed by Equation 2.

[Equation 2]

$$|V_{HD12} - V_{TE}| \neq |V_{HD34} - V_{TE}|$$

It is determined that tile has occurred, when the potential difference between the tracking error signal at the header 1,2 field and the reference level ($Vp1 = |V_{HD12} - V_{TE}|$) is not equal to the potential difference between the tracking error signal at the header 3,4 field and the reference level ($Vp2 = |V_{HD34} - V_{TE}|$). That is, as expressed by Equation 3, it is determined that tilt has occurred if the absolute value of the difference between the two potentials (=Vp1-Vp2) exceeds a threshold V_{Th1}. Otherwise, it is determined that tilt has not occurred if the absolute value of the difference between the two potentials (=Vp1-Vp2) does not exceeds a threshold V_{Th1}.

[Equation 3]

$$Vp1 - Vp2 \leq VTh1$$

As such, after calculation of the potential difference Vp1 between the tracking error signal at the header 1,2 field and the reference level, and the potential difference Vp2 between the tracking error signal at the header 3,4 field and the reference level, the difference between the two potential differences Vp1 and Vp2 is compared with the threshold, as a result of which the magnitude and the direction of tilt are detected.

When the difference between the two potential

differences Vp1 - Vp2 is α, the absolute value of α indicates the magnitude of tilt, the sign of α indicating the direction of tilt. That is, it can be detected whether the disc is bending up or down with respect to a normal state.

If the sign of α is negative (-), tilt is to be compensated by α in the positive (+) direction; otherwise, if the sign of α is positive (+), tilt is to be compensated by α in the negative (-) direction. That is, compensation for tilt has to be performed in such a direction as to equalize the two potential differences Vp1 and Vp2.

Because the values of the tracking error signals detected at the header 1,2 field and the header 3,4 field are variable depending on the disc, the ratio of the two signals is normalized as expressed by Equation 4.

[Equation 4]

$$\frac{Vp1 - Vp2}{Vp1 + Vp2} < V_{Th1}$$

That is, if the Equation 4 is satisfied, it is determined that no tilt has occurred, otherwise, it means that tilt has occurred, after which the magnitude and the direction of tilt are detected from the absolute value and the sign of Vp1-Vp2, respectively.

In connection with this, the tilt detector (204) calculates α in the above-described manner and outputs to the servo controller (205) tilt error signals indicating the magnitude and the direction of tilt, which correspond to the absolute value and the sign of α, respectively. The servo controller (205) converts the tilt error signals to a tracking driving signal and outputs the tracking driving signal to the tilt driver (206).

The tilt driver (206) moves the disc or the optical pickup for direct control of tilt based on the tilt driving signal, i.e., by the magnitude of tilt in the positive (+) or negative (-) direction. That is, tilt control is performed in such a manner that the potential difference ($Vp1 = |V_{HD12} - V_{TE}|$) is in symmetric relation with the potential difference ($Vp2 = |V_{HD34} - V_{TE}|$), or that $Vp1 - Vp2 \leq V_{Th1}$ is satisfied.

Such as in the present invention, during tilt or servo control, the quantity of tilt between the optical axis and the disc plane can be detected and controlled by any one of the above-stated methods.

The present invention presets the thresholds and reduces time required for detecting and compensating tilt during the actual data write operation, thereby enabling a real time write operation through rapid stabilization of tracking servo.

[EFFECT OF THE INVENTION]

As described above, according to an apparatus and method for recording/reproducing of optical recording medium, since the potential difference of a tracking error signal detected in a header field staged with respect to each other from a track center varies in accord with tilt, by using this characteristic, tilt is detected and compensated from variation of the potential difference of the tracking error signal during recording/reproducing actual data. Therefore, tilt can be detected and compensated in a stable and accurate manner without using a separate light-receiving element in a high-density optical disc and deterioration of data quality caused by tilt during a recording/reproducing operation can be prevented and stable operation of the system can be possible by preventing detrack caused by tilt.

It will be apparent to those skilled in the art than various modifications and variations can be made in the present invention.

Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is :

1. In an optical recording medium arranging a plurality of header areas being difference in phase as the non-writable areas for dividing shape of data area between writable data areas,

a method for recording/reproducing of an optical recording medium including the steps of:

determining whether a tracking error signal detected from areas having different phase in the non-writable area is symmetric or not based on the reference level;

deciding as "tilt-zero" if it is determined to be symmetric and deciding as tilt is occurred if it is determined to be asymmetric and outputting the resulting value; and

performing a tilt servo based on the resulting value.

2. A method for recording/reproducing of an optical recording medium as claimed in claim 1, wherein the reference level at the above step is a center level of a tracking error signal detected from the data area.

3. Deleted

4. A method for recording/reproducing of an optical recording medium as claimed in claim 1, wherein the tilt servo step performs a tilt servo in order for two tracking error signals having different phases to be symmetric each other based on the reference level.

5. In an optical recording medium arranging a plurality of header areas being difference in phase as the non-writable areas for dividing shape of data area between writable data areas,

a method for recording/reproducing of an optical disc including the steps of:

obtaining a difference value between a tracking error signal detected in the non-writable area and a reference level and outputting the resulting value to the 1 signal;

obtaining a difference value between a tracking error signal detected in a non-writable area having difference phase to the above non-writable area and the reference level and outputting the resulting value to the 2 signal;

deciding as "tilt-zero" if difference value of the 1 and 2 signals at the above steps is below the definite reference value and as tilt is occurred if exceeding the definite reference value and outputting the resulting

value; and

performing a tilt servo from the resulting value.

6. A method for recording/reproducing of an optical recording medium as claimed in claim 5, wherein the reference level at the above step is a center level of a tracking error signal detected from the data area.

7. A method for recording/reproducing of an optical recording medium as claimed in claim 5, wherein the tilt servo performing step detects the magnitude of tilt from the difference value between the 1 signal and the 2 signal.

8. A method for recording/reproducing of an optical recording medium as claimed in claim 5, wherein the tilt servo performing step detects the direction of tilt from the sign of the difference value between the 1 signal and the 2 signal.

9. A method for recording/reproducing of an optical recording medium as claimed in claim 5, wherein the tilt servo performing step compensates tilt in a direction that the magnitude of the 1 and 2 signals are equalized.

10. A method for recording/reproducing of an

optical recording medium as claimed in claim 5, wherein the tilt servo performing step detects tilt by normalizing the difference value of the 1 and 2 signals detected from areas having difference phase in the non-writable area.

11. In an optical recording medium arranging the 1 and 2 header areas being difference in phase for dividing shape of data area between writable data areas,

an apparatus for recording/reproducing of an optical recording medium including:

a servo error generator for detecting tracking error signals from the 1 and 2 header areas, respectively, and outputting to the 1 and 2 tracking error signals;

a tilt detector for detecting tilt by variation of the potential difference signal between the 1 potential difference between the 1 tracking error signal and the reference level and the 2 potential difference between the 2 tracking error signal; and

a tilt servo for compensating tilt detected from the tilt detector.

12. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 11, wherein the reference level of the tilt detector is a center level of a tracking error signal detected from the data area.

13. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 11, wherein the tilt detector determines as "tilt-zero" if the 1 potential difference is in asymmetric relation with the 2 potential difference and as tilt is occurred if the 1 potential difference is in asymmetric relation with the 2 potential difference.

14. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 11, wherein the tilt detector determines as "tilt-zero" if the difference value between the 1 potential difference and the 2 potential difference is below the definite reference value, and as tilt is occurred if the difference value exceeds the definite reference value.

15. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 14, wherein the tilt detector detects the magnitude of tilt from the difference value between the 1 potential difference and the 2 potential difference and detects the direction of the sign and outputs the resulting value to the tilt servo.

16. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 11, wherein

the tilt detector detects tilt by normalizing the difference value between the 1 potential difference and the 2 potential difference.

17. An apparatus for recording/reproducing of an optical recording medium as claimed in claim 11, wherein the tilt servo performs a tilt servo in order for the 1 potential difference to have a symmetric relation with the 2 potential difference.

FIG. 1

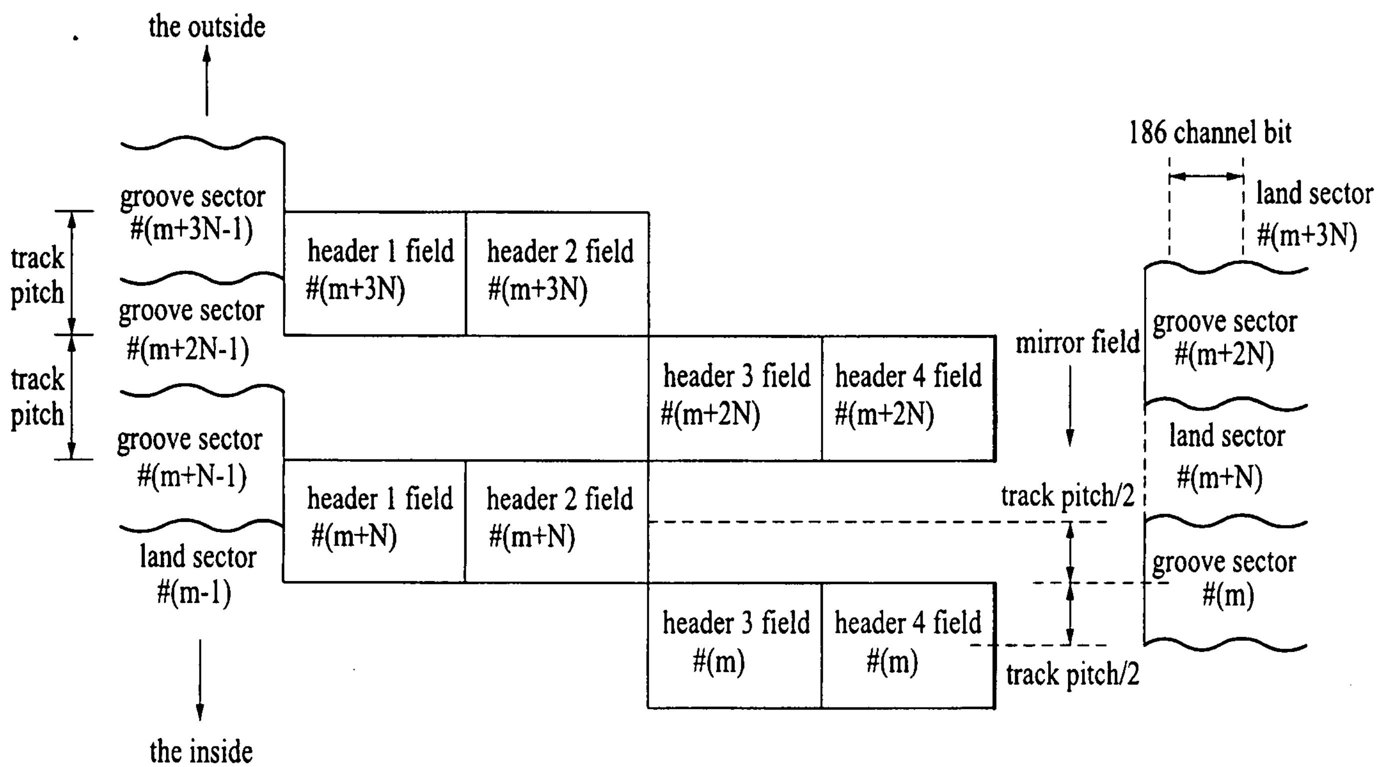

the outside
track pitch
track pitch
groove sector #(m+3N-1)
groove sector #(m+2N-1)
groove sector #(m+N-1)
land sector #(m-1)
the inside
header 1 field #(m+3N)
header 2 field #(m+3N)
header 3 field #(m+2N)
header 4 field #(m+2N)
header 1 field #(m+N)
header 2 field #(m+N)
header 3 field #(m)
header 4 field #(m)
mirror field
track pitch/2
track pitch/2
186 channel bit
land sector #(m+3N)
groove sector #(m+2N)
land sector #(m+N)
groove sector #(m)

FIG. 2

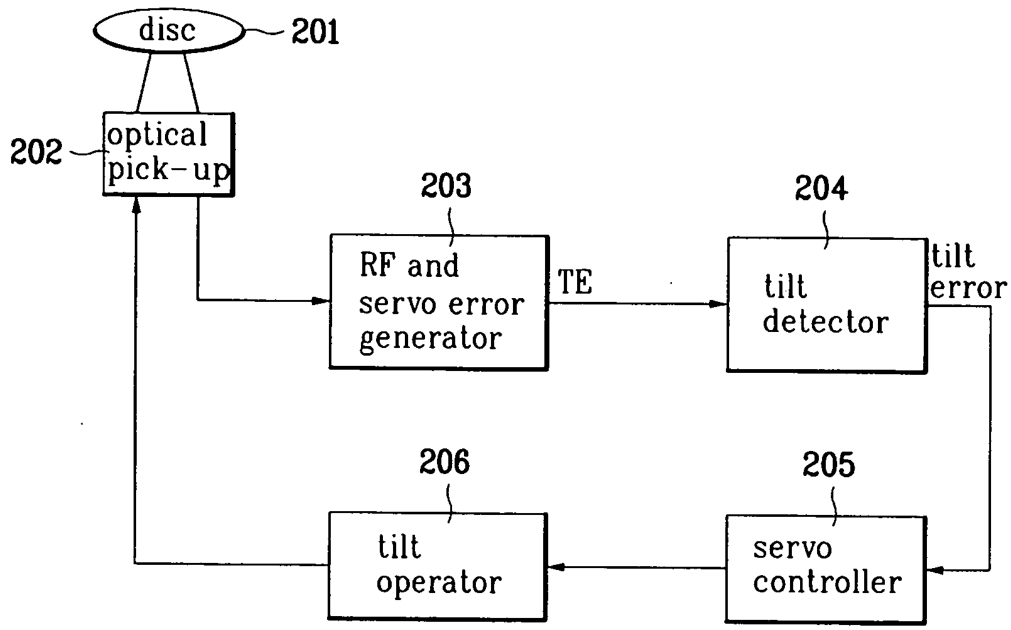

disc
201
202
optical
pick-up
203
RF and
servo error
generator
TE
204
tilt
detector
tilt
error
206
tilt
operator
205
servo
controller

FIG. 3

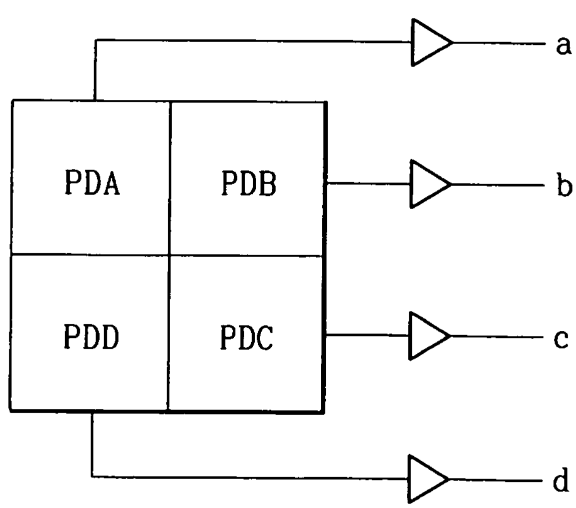

PDA
PDB
PDD
PDC
a
b
c
d

FIG. 4

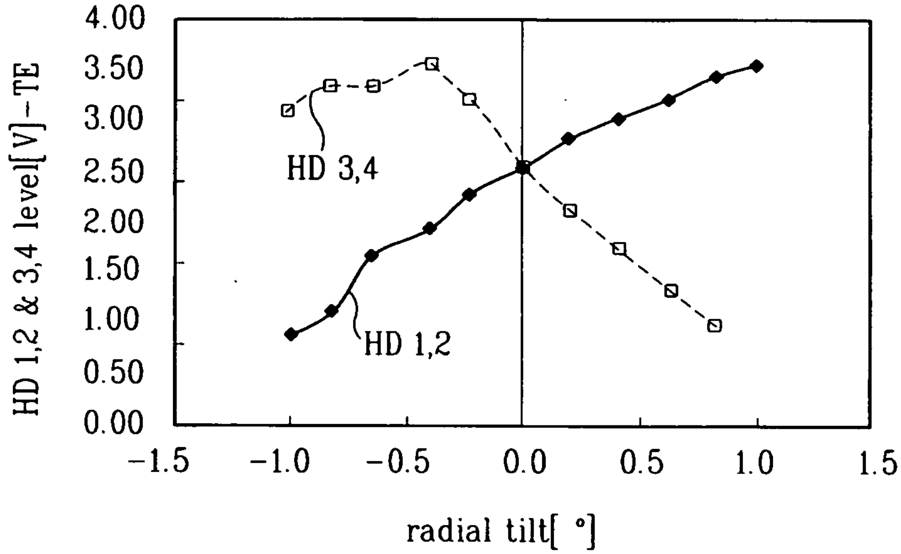
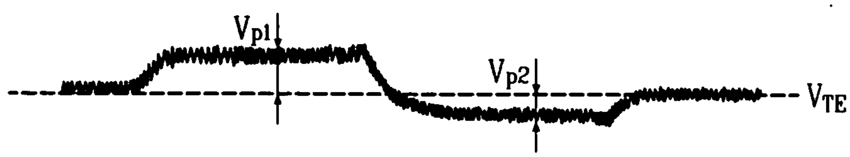
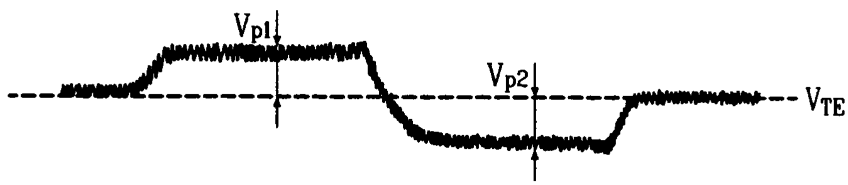

4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
HD 1,2 & 3,4 level[V]-TE
HD 3,4
HD 1,2
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
radial tilt[°]

FIG. 5a



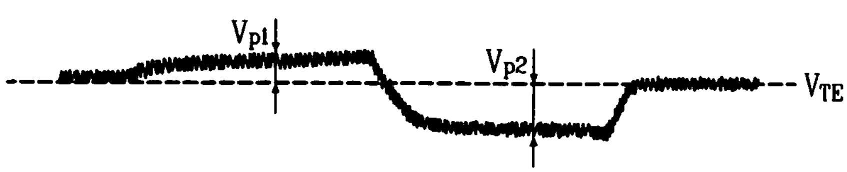
tilt=1, detrack offset=4.97
defocus offset=4.08

FIG. 5b



tilt=0, detrack offset=4.97
defocus offset=4.08

FIG. 5c



tilt=−1, detrack offset=4.97
defocus offset=4.08